Toward a Green California Hydrogen Highway:

Lessons learned from Solar, Wind and Biomass

Woodrow W. Clark II, Ph.D.
CEO/President
Clark Communications, LLC, San Francisco and Los Angeles, CA. USA

Stephen Irvin
PhD Candidate
University of California, Santa Barbara, CA. USA

Introduction

- Solar Industry
  - Pianeta "Sun Jump" Project in Italy
- Wind Industry
  - GE Large Scale Wind-Hydrogen Systems
  - Example: Tug Hill, Syracuse, NY
- Biomass Industry
  - California Bio Mass Consortium
- Cal State University – LA
  - Green Hydrogen Power Station

Solar

Pianeta "Sun Jump" Project

- The goal of this project is to provide low-cost and environmentally friendly energy to a natural gas substation where the pressure of natural gas is reduced and finally transitioned to a fully renewable hydrogen station.
- The area shown is part the methane pipe-line network of SEI S.p.A. of Settimo Torinese (near Turin) and is on-site power not on electricity grid.
- The investment for this solution is lower than the cost of a new connection to the electricity grid and there is no impact on the environment.

Pianeta "Primo Settimo " Project

Pianeta Photo: new headquarters of ASM Spa in Settimo Torinese (near Turin) Italy.

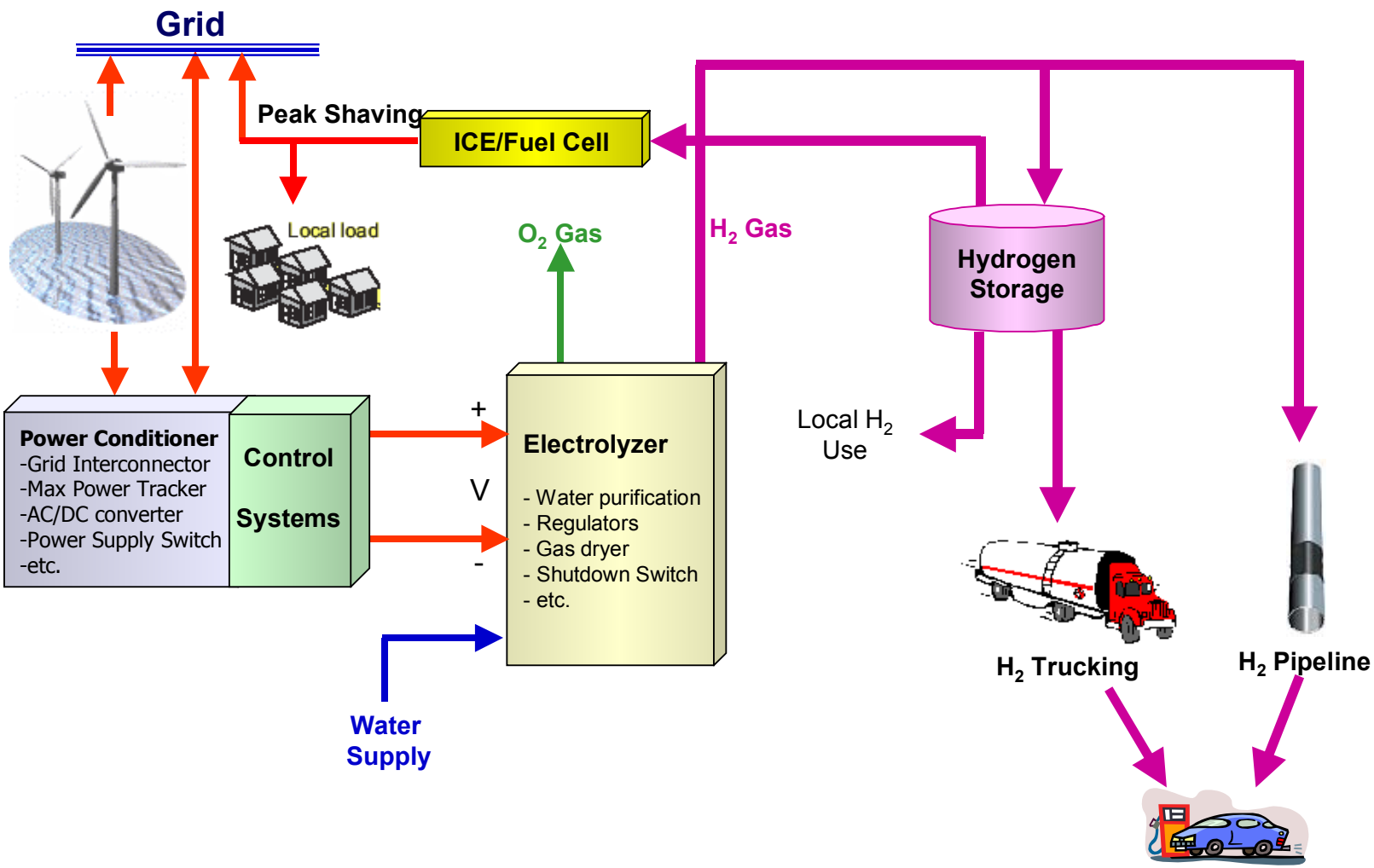
- To design and construct the first plant in Piedmont for the production, storage and use of hydrogen for energy purposes
- To demonstrate that it is possible to use hydrogen for energy production, with a lower investment and shorter pay-back period than that which has, until recently, existed.

Wind Industry

- Intermittent source - now predicable under CAISO and FERC Tariffs□□
- Uncertainties with Subsidies and Production Tax Credit under frequent political consideration
- Feed-in tariffs have worked best in European markets
- Cost reductions and local on-site through hybrid technologies
- System Benefit Charge for Public Benefits Fund
- Net metering and direct access rules need to be changed

GE Photo: 24 MW Klondike Wind Power Facility Wasco, OR.

Wind-Hydrogen System Concept



Wind-Hydrogen Forms a Green Energy Cycle and is Technically Feasible

H_2 Production - Pipeline Delivery (Tug Hill -Syracuse)

500 MW
$1000/kW
η ~ 40%

200 MW

200 MW
$1000/kW
η ~75%

O_2 Gas

3 gal/kg H_2

4500kg (150 MWh)
$100/kWh
η ~ 99%

Hydrogen
Buffer Storage

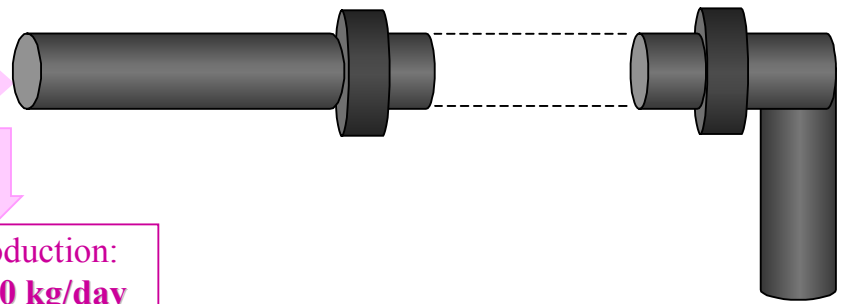
350 bar

6 MW
$1000/kW
η ~80%

4500 kg/hr, 25 bar

H_2 production:
108,000 kg/day
@ $3.4/kg

Plateau-Syracuse: 30 miles
Hydrogen pipeline
10" Diameter, 25 bar
$1MM /mile
η ~99% (30 miles)



H_2 production:
107,000 kg/day
@ $3.5/kg

Water Consumption
324,000 gal/day

Varnamo Bio Mass Plant, Malmo, Sweden

Biomass

NREL Photo: Wheelabrator Shasta 49 MW Biomass Power Plant
Anderson, CA.

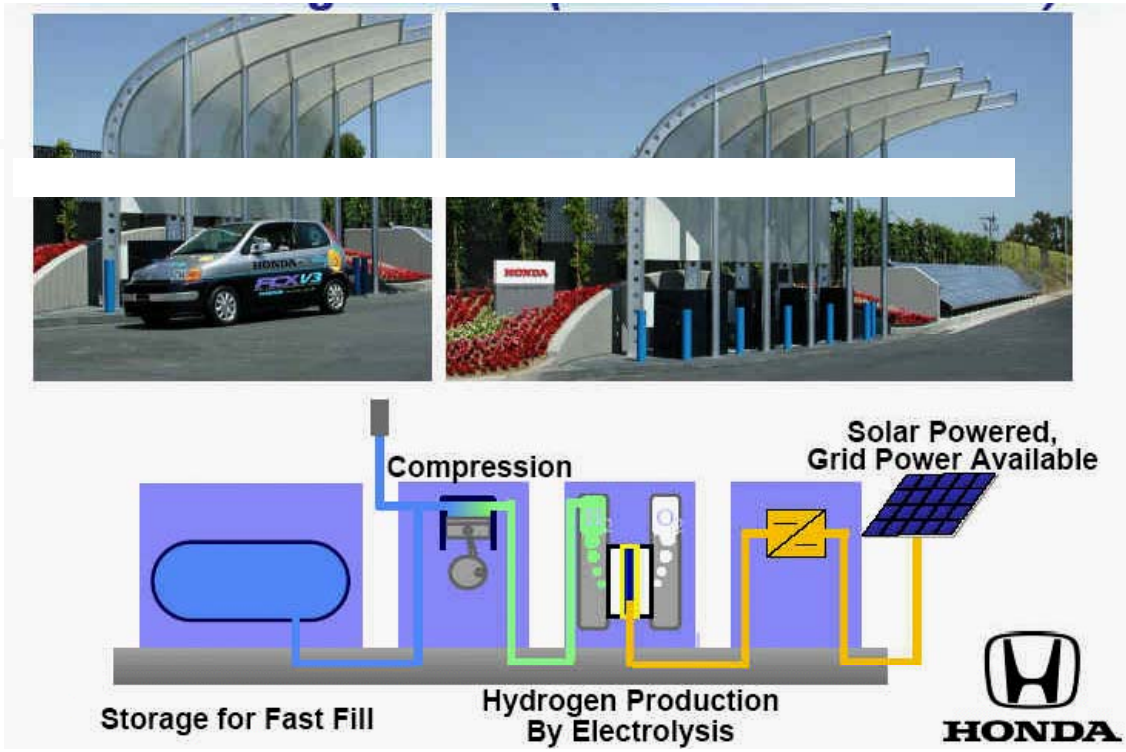
Cal State University - LA

CSULA - Estimated System Weight and Dimensions

Description	Quantity required	Model	Capacity	Length In	Width In	Height In	Estimated Weight lbs
Proton electrolyzer	1	HOGEN® H Series	200 scfh	78	32	78	1750
Carbon Fiber low pressure storage tank	1 tank	None	2800 scf	96	32 (diameter)		300
High Pressure Carbon fiber tank array	2	None	22304	96	144	72	3200
Compressor	1	PDC 4 - 6000	80 to 200 scfh	60	36	62	2300
Cooling unit for Hogen	1		16Kw	60	60	42	1800
FTI Dispenser	1	H1-412232	N/A	31.5	11.8	39.4	175


Administration - 8
Anna Bing Arnold Children's Center - 30
Arena Theatre - 2A
Biological Sciences - 13
Bungalows - C, D, L, Q, S, T, W, X
Career Planning and Placement - 17
Dolcini - 40
Engineering and Technology - 11
Fine Arts - 9
Fine Arts Gallery - 9A
Free Speech Area - 5A
Golden Eagle - 6
Gymnasium (Eagles Nest) - 10
Jesse Owens Track and Field - 18
Kennedy Library - 7
King Hall - 3
King Hall (Lecture Halls) - 3A
Los Angeles County High School for the Arts (LACHSA) - 7A
Luckman Fine Arts Complex -
Music - 2
Music Hall - 1A
NASA Research Lab - 11A
Physical Sciences - 12
Reeder Field (Baseball) - 24
Roybal Institute - 15
Salazar Hall - 15A
Simpson Tower - 15
Student Affairs - 8A
Student Health Center - 14
Student Housing Complex Phase I - 34, Phase II - 36
Theatre (State Playhouse) - 1
University Police - Bungalow C
University-Student Union - 5
VALLEY BOULEVARD
LEVANDA
MARIONDALE
PASEO RANCHO CASTILLA
LANSDOWNE
NORTH
HELLMAN AVE.
Lot F
Parking Structure II
Construction
Lot K
Residents Parking Only
Lot G
CIRCLE DRIVE
Library North
The Golden Eagle
Lot E
Palmer Wing
Lot H
INFO KIOSK
Lot D
Pool
Lot J
Lot I
Tennis Courts
H2 Fuel Station
HILLSIDE DR.
Greenlee Plaza and Underground Parking
Lot B
Police
Lot C
Lot A
CAMPUS RD
Construction
LONG BEACH FREEWAY (710)
STATE UNIVERSITY DRIVE
BUS/METROLINK STATION
EASTERN AVE.
SAN BERNARDINO FREEWAY (10)
RAMONA BOULEVARD
Emergency Phones
Disabled Parking
Pay Parking
Food Services
3 Minute Zone
20 Minute Zone

Honda Renewable Hydrogen Refueling Plant, Torrance, CA



CalTrans District #7 HQ

Los Angeles, CA

Conclusions: the road ahead

- Transformation from a global economy dependent upon fossil fuels to renewable fuels for an hydrogen economy is happening today worldwide.
- This “paradigm shift” is one as dramatic as the Industrial Revolution itself.
- Hydrogen economy is not an “adjustment” or “business cycle” or “bubble”.
- Implement “civic markets” as collaborations between public -- private sectors.
- California providing the initial “market driver” or public sector demand for new commercial emerging environmentally sound technologies for public and then private sector demand.
- Government should lead partnerships in an effort to combine infrastructures with advanced commercial hybrid technical systems
- Combine hydrogen for stationary power with future transportation fuel needs to expedite the paradigm change now in this Century.
- Immediate economic and business development for any region or nation-state.
- Production of hydrogen is derived from renewable energy resources, not only are there societal benefits but also sustainable economic growth.

Contacts for more information

Dr. Woodrow W. Clark II
Clark Communications, LLC
PO Box #17975
Beverly Hills, California 90209
Direct Number (310) 858 - 6886
Fax (310) 858 - 8661
Email wclark13@aol.com
OR
Stephen Irvin
University of California, Santa Barbara
(805) 686-5176
Email sirvin@bren.ucsb.edu